The Immediate Effect of Thoracic High Velocity Low Amplitude Thrust on the Upper Limb Neurodynamic Test 1 in an Asymptomatic Population- A Randomized Control Trial

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ABSTRACT

Objectives: The objective of this study was to determine the immediate effect of thoracic spine high velocity low amplitude thrust (HVLAT) manipulation on upper extremity neural tension by using the upper limb nerve tension test 1 (ULNTT1) in asymptomatic participants.

Design: A single-blinded, randomized, pretest-posttest design was utilized.

Methods: Block assignment was used to randomly allocate 33 asymptomatic participants (mean age 25 years) into either the experimental group, T-6 P-A HVLAT, or control group, lying supine for 5 minutes. A pre and post ULNTT1 were completed on each participant noting the participant's first self-perceived onset of discomfort or tingling (R1) and when the participant requested the test to be stopped (R2).

Outcome Measures: The outcome measures used for this study were elbow range of motion using an electronic goniometer during the ULNTT1 for the participant's self reported R1 and R2.

Results: The repeated measures ANOVA revealed a significant group to time interaction for R2 ($p = 0.03$). In the experimental group there was an increase in mean elbow extension of 6.7° compared to 1.6° in the control group. R1 failed to obtain a significant group to time interaction ($p = .117$). There was a trend towards significance with a mean increase in elbow extension of 5.9° in the experimental group compared to 0.57° in the control.

Conclusion: Our findings indicate that thoracic HVLAT has an immediate effect on decreasing upper limb neural tension in asymptomatic participants.

INTRODUCTION

Adverse neural tension (ANT) is a common sign associated to various pathologies seen by physical therapists in the clinic. Peripheral nerves are composed of varying collagen compositions that provide stretch, tensile strength and resistance to compressive forces from surrounding tissues to protect proper impulse

transmissions. Ideally, nerve and interfacing mechanical structures move independently; however, ANT results from changes in the nerve's mobility from altered neural tissue physiology.[1,2] As a result, ANT manifests through patient reported symptoms including pain, changes in range of motion (ROM), and limitations in the ULNTT.[2] ANT can also exist in asymptomatic individuals, resulting in limitations in ROM from decreased neural excursion.

Utilization of neurodynamic tests aids in assessment and appropriate treatment interventions in patients with ANT. The ULNTT1 is one neurodynamic test intended to evaluate the state of neural tissues and surrounding structures through passive upper extremity (UE) stretching and tension, specifically the median nerve. Other upper limb tension tests are utilized for radial and ulnar nerves in the upper extremity, taking the individual through each a different series of passive arm positions. These tests mechanically stimulate neural tissue to assess the mobility and irritability of the nervous system.[2-4] The series of the ULNTT1, used in this study, are outlined sequentially in figure 2 in the methods.[5] At the point the patient reports increased symptoms or tightness during the ULNTT1, the clinician can also feel and assess tissue limitations with a springy to tight end feel in the upper extremity.[6] Clinical findings of decreased ROM at the elbow joint combined with patient-reported symptoms localized to various areas can help physical therapists identify contributing musculoskeletal or other system involvement in a patient's condition.

Common interventions used to treat ANT include neural stretches and spinal mobilizations. Sweeney et al (1994) conducted a daily neural self-mobilization treatment program on patients with unilateral mechanical allodynia in the hand and found improvements in elbow extension ROM and patient reported improvements of symptoms after two weeks.[7] Mobilizing and stretching a nerve may decrease adhesions to surrounding structures causing remodeling and changes to physiological tissue structure.[8] These changes in turn alter tissue structure and have the potential to reduce patient symptoms and improve patient function. Proposed therapeutic benefits of neural mobilization and spinal manipulation include: stretching of shortened and thickened peri-articular soft tissues to improve range of motion, improving drainage of fluid within and surrounding the spinal segment, and changes in pain modulation, motor activity and proprioception.[9] Spinal manipulation is

biomechanically thought to alter sensory information input into the central nervous system by decreasing the nociceptive input from paraspinal tissues containing nerve endings, or hypoalgesia, and affecting pain processing at the spinal cord level via the gate control theory and a sympathoexcitatory input.[10,11] Significant improvement in pressure pain threshold and visual analogue scale pain rating has been associated with mobilization and manipulation in the thoracic spines of asymptomatic participants.[9,12,13] Consequently, spinal manipulation in conjunction with neural mobilization may improve ROM, increase function, and decrease symptoms in symptomatic individuals by incorporating treatment to the peripheral nerve and the spine.

Clinicians often use the idea of regional interdependence to treat musculoskeletal conditions. The term regional interdependence refers to the idea that supposedly unassociated impairments in remote anatomical areas involving different body systems may contribute or be related to a patient's primary complaint.[14,15] A patient's musculoskeletal system can be greatly impacted through neurophysiological and biomechanical pathways. Damage or inflammation to a nerve can result in musculoskeletal dysfunction.[6] Thoracic manipulation has been found to alleviate UE and neck pain in patients through the mechanism of regional interdependence.[16,17] Research supports that thoracic manipulation, both thrust and non-thrust techniques, cause neurophysiological effects and changes that improve pain and functional outcomes in individuals with musculoskeletal dysfunction.[17-23] In a systematic review, passive cervical joint mobilizations were found to improve sympathetic excitation, hypoalgesia, and positive changes in motor function, indicating that neural pathway controls act as a vital role in the neurophysiological mechanisms.[24] The interaction of various body systems has been shown to impact seemingly unrelated areas; therefore, the combined influences of regional interdependence, spinal manipulation, and a valid outcome measure, such as the ULNTT1, may provide further support to the positive outcomes of thoracic manipulation.

The various positive effects of HVLAT have been shown in research and in the clinic, but the effects on UE nerve tension have not been fully examined. The aim of this study is to determine the effectiveness of thoracic HVLAT on the upper limb neural tension by assessing the ULNTT1 in asymptomatic participants. To

our knowledge, no investigation has studied the effect of thoracic HVLAT on peripheral neurodynamic mobility in the UE in asymptomatic individuals.

MATERIALS AND METHODS

Trial Design

The study is single-blinded, randomized, pretest-posttest design. The allocation ratio was 1:1 for the experiment to the control.

Participant Consent

The study was approved by the institutional review board at Angelo State University. All participants were required to sign a written informed consent prior to their screening and participation in the study. The participant was free to withdraw at any time during the investigation.

Blinding

The participants and physical therapist performing the HVLAT were not aware of assignment until after the baseline measurement was completed and it was time to perform intervention or control. The rater administering the ULNTT1 was blinded to the allocation of groups for the entirety of the study.

Sampling Process

Participants were selected using convenience sampling. Two physical therapy students created a flier to recruit participants and communicated through email to assign participants to a day and time for data collection. To ensure similar sized control and intervention groups, block assignment was performed using excel.

Inclusion and exclusion criteria

The inclusion criteria for participants were: age 18 to 65 years with signed consent form. The participants were screened for exclusions prior to the study, including: history of previous or current acute circulatory condition, advanced diabetes, rheumatoid arthritis, cervicobrachial pain or numbness, open wounds, skin hypersensitivity to adhesive tape, pinched nerve, spinal fracture, spinal surgery, spinal infection, tumor, osteoporosis, steroid or anticoagulant therapy, hypermobility of the thoracic spine, pregnancy, restriction in UE ROM, or previously known adverse reaction to ULNTT1 or thoracic P-A HVLAT. A neurological examination was also completed by a licensed physical therapists to rule out findings suggestive of cervical nerve root or peripheral nerve involvement. The neurological examination consisted of: UE deep tendon reflexes, UE sensation testing, UE myotomes, Hoffman's reflex, and Spurling's A & B.

Participants

Thirty five participants passed the screening and inclusion process to be included in the study; however, two participants were found to have onset of symptoms in the starting test position for ULNTT1 and therefore were excluded. One additional participant was found to have an error in data collection, with failure to zero out the electrogoniometer, and thus was excluded after testing. This left thirty two participants, sixteen in each the control and intervention group, with data to be reported and analyzed (figure 1). The final sample included eighteen females and fourteen males, with a mean age of 25.4 (range 21 to 40 years).

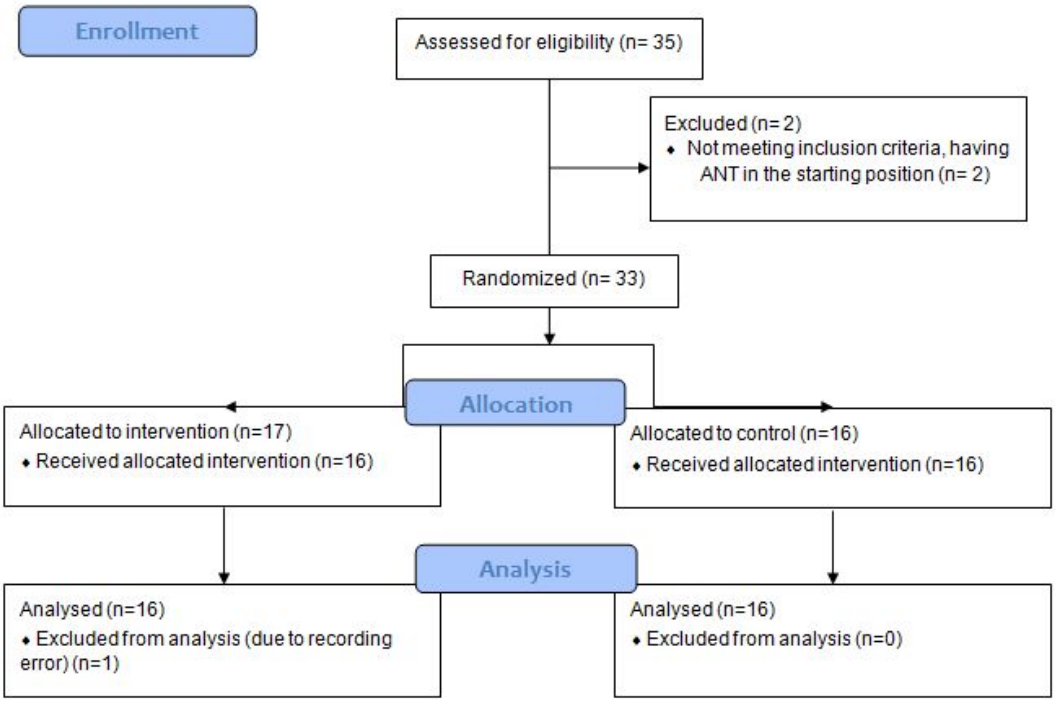

Figure 1: Participant Enrollment

Measurement Protocol

The ULNTT1 was the outcome measure used and was performed as described by Haddick (figure 2 and 3).[5] To safeguard reproducibility of the scapular depression component of ULNTT1, a ruler was used to mark the superior position of the scapula during the baseline measurement of each participant to recreate during the post intervention measurement. Measurements were recorded in degrees of flexion, or degrees lacking from full extension, from a baseline of zero degrees. The participant was placed supine in the testing position and was instructed by the rater to report first onset of tingling or discomfort which was measured as R1 and then to report when they desired the test to be stopped, which was noted as R2. To increase reliability, the rater performing the measurement was a doctor of physical therapy with over 30 years of clinical experience and specialized in outpatient orthopedics and manual therapy. To account for the serial effect at baseline, R1 and R2 were recorded on the fifth repetition.[4] Both R1 and R2 were recorded pre-treatment and post-treatment.

To ensure standardization of the testing position and alignment of each participant between measurements, a piece of tape was applied to the head of a high-low table. The participant was placed on the

high-low table in a supine position with no pillow, with the superior aspect of the participant's head aligned with the tape. The lower extremities were held straight and the left arm positioned at the participant's side with hand on abdomen. Stalioraitis et al (2014) failed to find a significant difference between dominant and nondominant elbow extension during ULNTT1;[25] thus for the purposes of this study, the right arm was arbitrarily selected for testing. An electrogoniometer (Twin Axis DataLOG W4X8; Biometrics Ltd, Gwent, NP11 7HZ, United Kingdom) was used to measure the degree of passive elbow extension during ULNTT1. Research has shown that electrogoniometers are a useful tool to use in both research and the clinic. Flexible electrogoniometers have been found both valid and reliable for measuring ROM in several studies including the elbow, knee, and wrist joints.[4,26-28] For this study, the lateral epicondyle served as the axis of elbow motion. For each participant, double sided tape held the axis arms of the electrogoniometer in place on the lateral shaft of the humerus and the radius. Once the electrogoniometer was applied, a tracing was made with a skin marker to ensure precise re-application in the event the axis arms dislodge during the thoracic HVLAT intervention. The display unit was placed next to the participant and the connection cables were also secured with tape. The electrogoniometer was zeroed out at zero degrees elbow extension before the ULNTT1 was administered on each participant. The readings were recorded by data recorders to ensure blinding of the examiner.

1. Scapula depressed and manually stabilized
2. Gleno-humeral joint positioned in 90˚ of abduction
3. Wrist and fingers in extension
4. Forearm in maximum supination
5. Shoulder full external rotation
6. Elbow extension
7. Structural differentiation

Figure 2: Sequence of movements during ULNTT1[5]

Figure 3 showing ULNTT1 testing position

Interventions

Five minutes was allocated for the treatment and control after the initial ULNTT1 measurements. Separate physical therapists administered the ULNTT1 and the intervention for blinding purposes. The rater conducting the ULNTT1 was not present during the intervention interval. For the control group, the participant remained supine and received no treatment for five minutes. In the intervention group, an experienced certified orthopedic manual therapist performed a supine thoracic P-A HVLAT using the dog technique as described by Casanova-Méndez.[29] The participant was positioned in a supine position with arms crossed over the chest. The participant's left arm closest to the therapist was placed inferior, and the therapist consistently stood to the left side of each participant. The therapist's left hand was placed underneath the participant's back on the bilateral transverse processes of T-6, and the right hand was placed over the participant's elbows. The contact area of the participant's elbows was inferior to the therapist's xiphoid process. The therapist administered a moment of flexion and posterior compression to remove slack from the joint, and the participant received a HVLAT in the anterior to posterior direction upon exhalation (figure 4). If an audible cavitation was not heard on the first attempt, the participant was repositioned and a second HVLAT was delivered.[29] After the HVLAT, the

participant was repositioned supine on the high low table in the initial starting position using the tape demarcations and left arm resting at the participant's side with their hand on their abdomen and the timer was allowed to run-out. After the designated five minutes for the intervention was completed, the rater performing the ULNTT1 re-entered the room. The ULNTT1 procedure was then repeated using the same protocol as the initial measurement in order to obtain a post-treatment measurement.

Figure 4 showing position for thoracic manipulation

Statistical Methods

The data was analyzed using the Statistical Package for the Social Sciences (SPSS) software 21 (IBM, Chicago, IL). All quantitative variables showed normal distribution ($P > 0.05$) with the Kolmogorov-Smirnov test, thus data was calculated using parametric assumptions. The groups quantitative baseline characteristics were compared using an independent t-test for quantitative variables and Pearson's Chi-square test for categorical variables with a P-value of < 0.05 chosen to indicate statistical significance. To determine intra-tester reliability of the ULNTT1 an intraclass correlation coefficient (ICC) was performed on the control group. The dependent variable of interest was the elbow range of motion during R1 and R2, therefore the pre and post-test mean and standard deviations were calculated for elbow extension in each group. The independent

variables were group (HVLAT and control) and time (baseline and post). An analysis of variance for repeated measures (ANOVA test) was conducted to determine group-to-time interactions.

RESULTS

The groups were evaluated for between group differences in demographics at baseline (table 1). The groups' baseline characteristic values were found to have no statistically significant differences. The intra-rater reliability on the control group was found to be excellent with an ICC of 0.927 for R1 and 0.934 for R2.

The study sample (n=32) was evaluated to compare between-group differences after intervention. Both groups demonstrated improvements in elbow extension after intervention or control. Mean improvements for the control group were 0.5 degrees and 1.6 degrees, for R1 and R2 respectively. Mean improvements in the intervention group were greater at 5.9 degrees and 6.7 degrees, for R1 and R2 respectively. Consequently, the interaction between groups for the experimental condition was significant for PostR2 (p= .03) and a positive trend towards significance was found with PostR1 (p= .117) (table 2).

	Experimental Group	Control Group	*P-Value*
Sample Size	16	16	
Gender Male (Female)	8 (8)	6 (10)	.476
Age	25.6	25.3	.463
Hand Dominance L (R)	0 (16)	0 (16)	
Mean Pre R1	34.3	42.2	.195
Mean Pre R2	22.5	25.3	.586

Table 1: Baseline Characteristics (R1 and R2 reported in degrees lacking from elbow extension)

	Pre-intervention Mean (SD)	Post-intervention Mean (SD)	Within-group diff Mean (95% CI)	Between-group diff	*P*-value
Control R1 Intervention R1	42.2 (21.7) 34.3 (10.2)	41.7 (17.8) 28.4 (12.1)	0.5 (-13.8 to 14.8) 5.9 (-2.18 to 13.98)	5.4	0.117
Control R2 Intervention R2	25.3 (17.8) 22.5 (11.0)	23.7 (13.4) 15.8 (12.3)	1.6 (-9.78 to 12.98) 6.7 (-1.72 to 15.12)	5.1	0.03

Table 2: Statistical significance of the between-group difference. (R1, resistance 1; R2, resistance 2; SD, standard deviation; CI, confidence interval) (R1 and R2 reported in degrees lacking from elbow extension)

DISCUSSION

As hypothesized, thoracic manipulation has a positive effect on increasing elbow extension measured by the median nerve ULNTT1 in asymptomatic healthy participants. Although the change in R1 was not statistically significant, the overall positive trend in the results indicates an association may exist, especially for future research with larger sample sizes. A study by Saranga et al (2003) also investigated the effects of manual therapy, specifically cervical lateral glides, on ULNTT1 and found similar results. When compared to a placebo and a control, the cervical lateral glides produced the greatest improvement in elbow extension using the ULNTT1.[30] This compliments our findings and suggests that the theory of regional interdependence could allow clinicians to influence neurodynamics using manual therapy. In the same study, Saranga et al (2003) hypothesized that the 7.1 degree improvement they recorded from one treatment could be clinically significant.[30] There is a lack of research to determine minimal clinically important differences (MCID), making it difficult to associate improvement in ULNTT to an improvement in patient reported symptoms. Further research should be done to determine the degrees of elbow extension needed to create a meaningful change for the patient.

Various changes in neurodynamics can create ANT and increase patient symptoms. Neurodynamic tests such as ULNTT1 are used in clinical settings to detect abnormalities in the neural tissue through patient self-reporting reproduction or increase in symptoms.[25] Minor nerve irritation caused by impaired vertebral

segmental motion may affect mechanical and physiological properties of the nerve, resulting in increased mechanosensitivity of the neural tissue.[31] These irritations can occur in both symptomatic and asymptomatic individuals. Although ULNTT1 requires self-reported symptoms that can vary between participants, we can be more confident in the accuracy of the measurements due to the excellent ICC found in this study (R1= 0.927 and R2= 0.934). The excellent ICC shows that the onset of symptom provocation within one participant can be detected reliably.[31] Other studies have reported similar intrarater ICC with values between 0.96-0.98, demonstrating that the ULNTT is a reliable outcome measure that can be utilized in the clinic.[31-33]

While the effects of spinal manipulation on neural tissue are still being investigated, research has thoroughly demonstrated positive effects through pain relief and improvement in overall functional mobility.[9,12,13] Numerous biomechanical and neurophysiological influences may explain the positive association of thoracic manipulation to improving elbow extension in this study. Neural tension can be created as a product of other surrounding and interfacing structures impinging on the tissue, causing a loss of neural tissue mobility and increasing mechanical irritability of the nerve. Neural compression compromises axoplasmic flow reducing the transport of neurofilaments, microtubules, and neurotransmitters along the axon and the return of metabolic byproducts, potentially altering the neurophysiology and function.[2] Intra-articular biomechanical and neurophysiologic effects can both occur after HVLAT manipulation.[34] Neurophysiologic changes in group la and group II mechanoreceptor discharge, sensory processing facilitation in the spinal cord, and control of skeletal muscle reflexes have been found to occur in response to spinal manipulation.[10,35] Manipulation elicits a sympathetic nervous system response by stimulating dorsal peri-aqueductal gray matter and consequential pain relief.[12] Biomechanically, ANT can be improved through spinal mobilization and manipulation by stretching shortened and thickened peri-articular soft tissues and causing improved drainage of fluid within and surrounding the spinal segment.[9] In our study, the combination of the elicited sympathetic reaction with the intervertebral joint capsule stretch may alleviate pressures from surrounding tissues on the nerve, allowing the participant's elbow to be passively placed into greater extension. Considering the ULNTT1 relies on self-reported sensation of symptoms in the participants, it is possible that creating a change in sensory

processing through spinal manipulation could affect the results and allow the patient to extend the elbow further without symptoms.[31] It is also reasonable to assume that acting on the external structures causing adverse changes to the neural tissue, would also improve neural tissue mobility. Although there are numerous sources for ANT in a patient, there are also numerous positive benefits proven in research that can act on these sources and ultimately improve the patient's function.

We must consider other explanations for the increase in elbow extension found in this study. Repeated repetitions of the ULNTT1 have shown to have statistically significant improvement in elbow ROM, indicating that increases in elbow extension could also be attributed to repeated ULNT testing alone; therefore, further investigation on the mobilization benefits of the ULNTT itself may be beneficial for future treatments. These differences varied between participants and were found to be transient, disappearing after a minute rest break.[4] As mentioned in the methods section, we recorded baseline measurements on the fifth trial in order to reduce these serial effects. The placebo effect may have been another influential factor to consider. Although participants during the study were not educated beforehand on the potential benefits of manipulation, the individuals were still aware if they were receiving the manipulation intervention or not. It is possible that the knowledge of receiving a treatment could have caused the participants to subconsciously allow the tester to continue the ULNTT1 further to create a greater change compared to the control.

To our knowledge, no research has been conducted to investigate the effect of thoracic HVLAT on peripheral neurodynamic mobility in the UE in asymptomatic individuals; therefore, this study is considered a pilot study. The positive trends found in this study could be used in future research investigations with larger sample sizes and on patients with symptomatic ANT. Using larger samples and testing the HVLAT effects on a symptomatic population would further enhance clinical applicability.

Study Limitations

There are several limitations to this pilot study including small sample size, short time frame and data collection error. Small sample size may have contributed to lack of obtaining statistically significant R1

measurements. Having a larger sample size in further research would be beneficial to establish power in the study. The effects of the ULNTT1 were assessed immediately post-treatment. Assessment of results over a moderate to long time span in addition to short term effects would improve clinical significance. As mentioned in the methods section, one participant's measurements were not recorded correctly and in turn were not included in the results.

CONCLUSION

The purpose of this pilot study was to measure the clinical effectiveness of thoracic HVLAT on decreasing upper limb nerve tension through the ULNTT1. Elbow extension improvement was statistically significant for R2 and a positive trend towards significance was demonstrated in R1 between groups. While elbow extension increased in both groups, the difference was more substantial in the intervention group. Through the theory of regional interdependence HVLAT manipulation is able to create biomechanical and neurophysiological effects to improve neural tissue limitations. Further studies on HVLAT thoracic manipulation effects on the immediate and long-term improvement of elbow extension during the ULNTT1 should be examined in symptomatic populations. The results of this study provides clinicians with foundational evidence regarding the use of thoracic spinal manipulation to improve UE neural tension and the eventual establishment of clinical MCIDs.

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